Administrative Order on Consent Amendment Study Work Plan Smelter/Tailing Soils Investigation Units

Chino Mines Company
Hurley, New Mexico

August, 2006

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REPORT

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Respectfully submitted,

BLASLAND, BOUCK & LEE, INC.

REBECCA LINDEMAN
NEW MEXICO
16777
LICENSED PROFESSIONAL ENGINEER

Rebecca Lindeman

Rebecca D. Lindeman, P.E. License #16777

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Project Description and Site Background

On December 23, 1994 Chino Mines Company (Chino) and the New Mexico Environment Department (NMED) entered into an Administrative Order on Consent (AOC) to address the possible environmental impacts within the Investigation Area (IA) due to mining operations, historical releases, and natural sources. The upland Smelter and Tailing Soil Investigation Units (STSIUs) are two of the six investigation units within the IA. Copper is the contaminant of concern within the surface soil in the STSIU from human health and ecological risk perspective.

This work plan follows the guidance for pilot-scale treatability work plans found in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988).

1.1 Site Description and Background

This section describes the Site, and focuses on the STSIU where appropriate. Site setting, physical features, geology and climate are discussed below.

The Site was described in detail in the *Remedial Investigation Background Report - Chino Mine Investigation Area* (Chino, 1995). This site description was updated for the STSIU in the Remedial Investigation (RI) (SRK, 2005). The following description of the Site is mainly adapted from these sources, in particular the RI.

Multiple investigation units (IUs) associated with mining and smelting operations at the Site were designated in Appendix A of the AOC. These included the Lampbright IU, Hanover Creek IU, Whitewater Creek IU, Smelter IU, Hurley Soil IU, and the Tailing Soils IU. The Hanover and Whitewater Creek IUs have since been combined to form the Hanover/Whitewater Creek IU. The Smelter and Tailing Soils IUs have also been combined to form the STSIU. Figure 1 presents a Site Overview map.

The STSIU includes the copper smelter, ancillary facilities including the former Hurley Concentrator, and the tailing disposal facilities. The AOC defines the tailing area as all soils adjacent to the Chino tailing pond facility and those soils shown to be potentially affected by the tailing. This Amendment Study Work Plan focuses on select areas to the west, north, and east of the former smelter.

The Hurley Smelter, located in Hurley, New Mexico, is bounded by the Town of Hurley to the west, Whitewater Creek to the northeast, Lake One to the east and the tailing impoundments to the south. Current land uses adjacent to the smelter are residential in the towns of Hurley and North Hurley, tailing disposal south of the smelter, and livestock grazing elsewhere. Chino owns the majority of the land within the STSIU, with the exception of private residential areas. The majority of Chino-owned land located west of Highway 180 and east of Whitewater Creek is currently leased for livestock grazing.

Chino maintains 24-hour, 7 days a week security within the smelter operational area. Motor vehicle access to the operational area is controlled via locked service entrances or manned security gates. Perimeter fencing around the smelter operational area inhibits pedestrian access. Further, Chino security routinely patrols the former Smelter IU area to the east of Whitewater Creek to prevent unauthorized access.

The STSIU is located primarily within the San Vicente Basin, a broad lowland area characterized by several dry washes and gullies with sandy bottoms. Areas west and north of the smelter and tailing facilities are relatively flat at an approximate elevation of 5,700 feet above mean sea level (msl), while increasing topographic relief is observed to the northeast and east, rising to an elevation of approximately 6,400 feet above msl. Soils are generally rocky and thin with little organic material.

The Site is located within a complex geologic region that constitutes a transition zone between the Colorado Plateau to the north and the Basin and Range structures to the south. This transition zone is a northwest-trending structural belt, 50 to 75 miles wide, and is characterized by features related to Late Cretaceous and Miocene intrusive activity. The primary surficial geologic units in the STSIU are rhyolite, Gila Conglomerate and alluvial deposits. The rhyolite consists of welded tuff. The Gila Conglomerate consists predominantly of poorly sorted, unconsolidated to highly consolidated sand, gravel and silty gravel, deposited as coalescing alluvial fans. Alluvial deposits, associated with drainages and stream channels, are similar to the Gila Conglomerate in composition. The most predominant alluvial deposits in the vicinity of the STSIU are sediments from Whitewater Creek.

Whitewater Creek runs along the eastern side of the Hurley Smelter and tailing ponds. Field observations indicate that surface water flow in Whitewater Creek occurs ephemerally after significant rainfall events. Runoff events in the upper reaches of Whitewater Creek typically infiltrate into the streambed before reaching the STSIU.

The property is located in a semi-arid region of southwestern New Mexico. The site has a low relative humidity and exhibits a wide range in daily and annual temperatures. Average monthly temperature measurements, recorded at the Fort Bayard weather station (north of Hurley), range from a low of 38.4°F in January to a high of 72.5°F in July. The average annual temperature is 55.1°F. The average annual precipitation is 15.4 inches per year with most of the rainfall occurring during July, August and September as brief, but occasionally high intensity, thunderstorms. The prevailing wind direction is from the west-northwest with an average wind speed of approximately eight miles per hour.

1.2 Project Description

The goals of this Amendment Study are to determine:

- effectiveness of lime as an amendment;
- rate of application of lime and organic matter;
- method for application and tilling; and
- natural revegetation percentage as a result of the lime and organic matter.

Results of this study will be used to determine if lime amendment and tilling is an effective remedial action to address the elevated copper concentrations and depressed pH for full-scale implementation of approximately 700 acres of uplands. If successful, the pilot study would be used as a basis for an interim action which would be submitted subsequently as a formal workplan under separate cover.

Based on the surface soil copper concentration data, the area of upland soil with surface soil copper concentrations greater than 5,000 mg/kg is approximately 150 acres to the east of the smelter operational area and approximately 240 acres north of Hurley (390 acres total) (Figure 1). The areas with copper concentrations greater than 5,000 mg/kg are not part of this Amendment Study and will be managed under an Interim Action Work Plan (IAWP) for excavation, to be submitted under separate cover. These areas are limited to portions of the uplands located directly downwind from the smelter and adjacent to the smelter operational area.

The areas associated with copper concentrations less than 5,000 mg/kg but greater than 2,700 mg/kg are the focus of this Amendment Study, and are approximately 230 acres to the east of the smelter operational area and approximately 258 acres to the west and north of Hurley (Figure 1). Derivation of the copper concentration range is described in Section 2.1, below.

A ¼ acre section at each of four impacted areas (West of Hurley, North of Hurley, North East of Hurley [East A], and East of Hurley [East B]) will be utilized for this study. Areas, such as, North of Hurley and East A, where the copper concentrations are less than 5,000 mg/kg but greater than 2,700 mg/kg and rangeland condition is poor, will be amended, tilled, and restored as necessary. Areas West of Hurley and East B, where the copper concentrations are less than 5,000 mg/kg but greater than 2,700 mg/kg and rangeland condition is fair/good will be amended without tilling (i.e., spray amended). Rangeland condition is defined in Section 2.2, below. The target amendment zone is 8-inches below grade.

Remedial Technology Description

Chino has selected use of lime and organic matter based on existing soil conditions and the overall goals of improving soil quality such that vegetation growth is improved as compared to surrounding areas. Lime amendment will increase the pH such that the copper is less available (e.g., less soluble) in the near term. However, establishment of a good vegetative cover will provide for long term binding of the copper within the root zone of the soils. Technical considerations are discussed in more detail in Section 4, below.

It has been shown that organic acids, particularly the fulvic acid component is known to form stable complexes with copper. These complexes are most likely a result of chelation. Increased pH (optimum at approximately 6.5) also facilitates complexation with copper. This is likely a result of increased ionization of carboxylic and phenolic functional groups on the fulvic acids. Thus, organic matter and liming at this site will be important in complexing and reducing the cupric ion activity (free Cu^{+2}) within the surface soils (Schnitzer and Kodama, 1977). The lime will react to neutralize acidity forming water and leaving calcium ions in the soil. Thus, the effects of lime will diminish over time. However, the soil organic matter component will be important in facilitating the complexation of cupric ion activity (Cu^{+2}) in the long-term and providing a sustained release of nutrients over time, which will be important in the establishment of vegetation on-site. As vegetation becomes established, soil organic matter content will increase until an equilibrium is reached. This equilibrium will be a function of the type of vegetation and site-specific conditions, particularly soil moisture and temperature.

Thus, the benefits of an adjusted pH and increased organic matter will be two-fold. The amendments will help complex Cu^{+2}, moving it away from the soil surface but keeping it complexed with organic acids in the upper part of the profile. The amendments will facilitate revegetation of the site, which will be important in stabilizing the high Cu soils and improving habitat quality and rangeland condition.

Test Objectives

The results of this Amendment Study will be utilized to develop an Amendment IAWP for the 230 acres to the east of Hurley and 258 acres to the west and north of Hurley. The following steps describe the path forward for the STSIU:

- implement this Amendment Study in August 2006;
- sample the amended soils during the rainy season of 2006 to ensure that the target pH has been attained;
- stabilize the soils to protect against excessive erosion and sedimentation within the disturbed areas;
- Monitor the amended areas for vegetation regrowth by measuring percent cover;
- prepare the Amendment IAWP in fall 2006 utilizing results of monitoring of the Amendment Study; and
- revegetate, as necessary, immediately prior to the 2007 rainy season in those areas where vegetation has not reestablished naturally.

The success of this amendment study and applicability for full-scale implementation will be determined based on the following metrics:

- Reduced solubility of copper within the top 6-inches of soil as compared to pre-amendment baseline conditions. The target percent solubility reduction will be determined after pre-amendment soil samples are analyzed and interpreted. For the purpose of this Amendment Study, the percent reduction is a quantitative measurement with target to be set as part of this Study;
- Sustained pH levels within the target range of 5.5 to 6.5 during the 6-month monitoring period;
- Increased plant cover percentage as compared to existing vegetation and the control plot. Target for this Amendment Study is 70-100% plant cover as compared to the average percent plant cover within surrounding areas (considered baseline). Composition or speciation will not be used as a metric as several years may be necessary to develop plant diversity during natural revegtation; and
- Improved soil chemistry (e.g., C/N ration and concentration of nutrients) is sustained over 6-month monitoring period. C/N ratio stability over 6-months will provide a measurement of longevity of the OM addition within the target mixing zone of 8-inches bgs. Improved chemistry is assumed to have been achieved if the C/N ratio after amendment is higher than pre-amendment ratios. Sustainability of the increased C/N ratio is the true metric for performance and permanence.

Design parameters and installation methods are described in more detail in Section 4.0.

Pilot Study Design

4.1 Copper Concentration and pH

Copper has been identified as the driver constituent for this interim action. Based on the Advisory Group Formal Dispute Resolution for the Chino AOC, Hurley Soils Investigation Unit (HSIU), an amendment to the AOC dated July 28, 2005 set a pre-feasibility study remedial action criterion for the Hurley Soils Investigation Unit of 5,000 mg/kg for copper in soil to be protective of human health (Phelps Dodge Corporation, 2005). The areas with copper concentrations greater than 5,000 mg/kg are not part of this Amendment Study and will be managed under an Interim Action Work Plan (IAWP) for excavation, to be submitted under separate cover. These areas are limited to portions of the uplands located directly downwind from the smelter and adjacent to the smelter operational area.

A soil concentration of 2,700 ppm copper was derived based on protection of the small ground feeding bird population. Based on the results of the Final Ecological Risk Assessment (Newfields, 2006), vegetation and especially grasses are affected by soluble copper regulated via soil pH and total organic copper. However, it has been shown that soil pH is quite variable within the STSIU and thus the pilot study will target areas associated with copper concentrations less than 5,000 mg/kg but greater than 2,700 mg/kg with their associated pH levels which are also be depressed. This copper range addresses a grey area within the STSIU that is not a concern for human health but may be an issue for local populations of small ground feeding birds. In addition, by addressing pH for this area, the vegetation will also be restored which will support all wildlife including small ground feeding birds.

4.2 Rangeland Condition

Rangeland condition is affected by a number of factors including soil type, pH, elevation, and aspect; precipitation and vegetation pattern formation; human use, grazing, and fire patterns; and plant and wildlife adaptation as an effect of soil mineralization and mining impacts. Detailed descriptions of these factors for the STSIU are presented in the ERI (Arcadis JSA, 2001). Phytotoxic effects from copper could occur at the site due to elevated copper concentrations and depressed pH in site soil. The potential for direct phytotoxic effects and cascading adverse effects and secondary stressors resulting from habitat loss are of concern. Potential adverse effects could include increased erosion, nutrient runoff, penetration of pests, weeds, and other exotic species, and altered hydrologic regimes. Although impacts from mining activities may have affected rangeland conditions in the STSIU, the interaction of other environmental and anthropogenic stressors, such as climate and grazing, is complex. All stressors were preliminarily characterized in 1997 as part of a rangeland condition study conducted by Chino under the Phase I Ecological IU RI Proposal (Woodward-Clyde, 1997).

The Phase I Ecological IU RI Proposal cited standard federal land management agency procedures for classification of rangeland according to ecological condition (Woodward-Clyde, 1997). Rangeland condition or ecological status are measured as the degree to which the vegetation of a site is different from the potential natural community characteristics of that or similar sites. Rangeland ecological condition was evaluated based on three major ecological attribute categories: (1) degree of soil stability, (2) integrity of nutrient cycle, and (3) presence of functioning recovery mechanisms. These attributes as measured by soil condition, plant composition, and plant cover, were the principal attributes used to rank and classify landscape unit (i.e., polygons) ecological conditions for the STSIU into an observed apparent trend (OAT). In addition, preliminary rangeland condition categories:

excellent, good, good-fair, fair, fair-poor, and poor were also recorded. These preliminary rangeland conditions for the STSIU are presented on Figure 2. As shown on Figure 2 rangeland conditions in the STSIU range from poor to excellent.

4.3 Amendment

Adjusting the pH is important for a number of chemical and physical effects in the soil. A pH in the range of approximately 6-7 provides for readily available plant nutrients as well as increased bacteria and actinomycetes populations. Fungi function well across a range of pH from greater than 4 to less than 9. The solubility of copper will also decrease within this range. Lime will be used as a source of calcium (Ca). The calcium (Ca) will eventually help to increase soil structure and facilitate infiltration of rainwater into the soil thereby reducing runoff from the amended area. With sodium (Na) in the system, Ca will readily replace it on the exchange, which will also help to increase infiltration capacity of the soil mass.

Lime will applied as a slurry (oxide or hydroxide) in order to increase the application rate and minimize dust generation during application and subsequent tilling (within the two areas with poor vegetation).

The amount of lime to be used is a function of a number of factors including surface and subsurface: pH, cation exchange capacity (CEC), texture, structure, type of lime, and amount of organic matter. A soil buffer equilibration is used in lieu of specific laboratory analyses for determination of pH (e.g. SMP, Double-Buffer SMP, Adams and Evans, etc.). These methods take into account the "reserve" acidity as a function of the CEC, as well as other acids in the soil. In the low pH areas, more than one application may be necessary to achieve a satisfactory pH level to establish revegetation.

For this Amendment Study, BBL assumes the following:

- The surface texture of the pertinent soils is dominantly sandy loam.
- The bulk density is comparable to numbers from the literature for sandy loams (e.g. ~1.6 Mg/m^3).
- The CEC is similar to other sandy loams given in the literature.
- The CEC is dominated by acid (hydronium ion).
- The lime used will have a high fineness factor and low moisture content.

To determine the best application rate, the lime application rates may be varied within each plot based on pre-amendment soil chemistry. Depending on soil characteristics, it is possible that up to 30 tons of lime/acre (multiple applications) may be needed to raise the pH from 2 (an extreme low) to 6.5 (a relatively high number) to allow for revegetation. As for the other areas that have a more neutral pH, liming is not generally recommended if the pH is above approximately 5.6.

In sandy soils which sometimes record lower pH values with a high SMP buffer value and where fertilizers have not been applied, light applications (1-2 T/acre) of lime generally suffices to neutralize soil acidity. BBL assumes these rates will be appropriate in more "neutral" pH areas. For this reason, BBL recommends rates of 2.0 to 2.5 T/acre in the West and North areas where pH may be close to 5.0.

In those areas where the lime will be applied as a slurry, it will be important to add the slurry in a low-intensity, longer duration application to avoid erosion and shallow subsurface movement of the slurry.

Sample Calculation

For the hectare furrow example: $10{,}000m^2$ (0.15m) ($1.6Mg/m^3$) = 2.4×10^6 kg/hectare-furrow slice. "Typical" surface soils weigh about 2.2×10^6 kg, with comparable values in the English system of 2.0×10^6 lbs/acre-furrow slice (Brady, 1984). An acre-furrow slice is an agricultural and soil science term that simply denotes an acre of soil to six inches depth.

Since existing data indicated the upper part of the profile was sandy to sandy loam, BBL assumed a slightly higher bulk density of 1.6 Mg/m^3 (which is typical for sandier soils) which, after conversion, gave an approximate value of 2.1×10^6 lbs/acre-furrow slice. Thus, this is the value used in calculating mass of organic matter as a function of percentage and cmol/kg acid and the amount of $CaCO^3$ (Ca^{+2}) to neutralize potential soil acidity.

In the absence of soil "buffer" data, BBL assumed a CEC consistent with sandy soils with low clay and organic matter content (10 cmol/kg). As an example: 1.0 mol of charge associated with H^+ will be replaced with the equivalent charge of ½ Ca^{+2}. Thus, one mol (1.0 g) of H would exchange with ½ mol (20g) of Ca^{+2} and 1.0 centimole of H^+/kg will require 0.2 g Ca^{+2}/kg soil.

If we assume a hectare-furrow slice of soil (i.e. a hectare area plowed to 15 cm (6 in) depth) with a CEC of 10 cmol/kg that is dominated by acid then 480 kg of Ca (from $CaCO_3$) or 1200 kg $CaCO_3$ would exchange and neutralize 1 cmol H+/kg soil. Thus, 12,000kg $CaCO_3$ will exchange and neutralize 10 cmol H+/kg in a hectare-furrow slice. This value translates to 10,700 lbs of pure $CaCO_3$ per acre furrow-slice **(5.4 T/acre).**

If we use $CaCO_3$ with a relatively high fineness factor (0.9) and low moisture factor (also 0.9) we have a lime score: 100 x 0.9 x 0.9 = 81
Therefore we would need: 5.4/81 x 100 = **6.6 T/acre** to exchange and neutralize 10cmol/kg acid. Note that this is slightly less than the 7.8 T/acre application used in the Basin Creek Mine site in Southwest Montana, which has low pH (~2.0) soils.

Thus, compared with similar sites these application rates are reasonable.

4.4 Organic Matter Amendment

Organic matter (OM)/organic carbon can serve as a buffer to soil acidity. OM in arid soils is generally low as a result of drier, oxidized conditions. Soil organic matter is also relatively small in well drained mineral soils, ranging from two to six percent by weight. Six percent is a high-end "equilibrium" number. In light sandy loams it is difficult to get soil OM up to or above four percent. For the purpose of this study, one percent of OM is assumed to be already in the soil at the site. The goal would be to raise the OM content to approximately three percent. Three percent organic matter content was selected as an intermediate number between very high organic matter contents (e.g. 5 – 7 percent in some prairie soils) and low content (e.g. less than 1 percent in some sandy soils). Maintaining high levels of organic matter can be expensive, especially in oxidized sandy soils and arid environments. In this particular location, soil organic matter will be important in providing slower, long-term release of N and C. In the absence of data on soil organic matter/carbon, an intermediate value between low and infeasible (very high) is a reasonable choice.

The are two main types of amendments for OM incorporation are solid (compost) and sludge from local municipal plants (solids and liquid). Sludge application would not be desirable since it can be high in metals.

There are approximately 2.1 x 10^6 lbs mineral soil per acre-furrow slice (i.e., approximate weight of the mineral soil in an acre plot to six inches in depth). Two percent by weight is approximately 20 tons compost per acre. The C/N ratio of the compost should be between 20:1 to 30:1. Legumes and “farm manures” have these lower ratios. Straw residues and sawdust should be avoided since their C/N ratios can range from 100:1 to 400:1 and can adversely affect plant growth if microbial populations are present in the soil. C/N ratios in the furrow-slice in arable soils range from 8:1 to 15:1 with the median between 10:1 and 12:1.

OM will be applied following lime application in each of the four amendment study areas. Manure has been selected as the OM for use during the amendment study. One sample of manure will be field analyzed for metals. The C/N ratio will be determined based on laboratory analysis of the sample. Application rate may be adjusted based on the calculated C/N ratio of the manure to achieve the target C/N ratio in the amendment zone of between 8:1 and 15:1. Section 3.0 below, describes the soil sampling program.

4.5 Revegetation

Given the high metal concentrations, acidic soil characteristics, and extreme / punctuated moisture, temperature, and wind fluctuations on the Hurley facility (and proximate lands), plant selection is focused on “phytostabilization” and not “phytoremediation” of the heavy metal concentrations. Phytostabilization is the process in which plants are used to immobilize metals in the soil (and thus minimize their mobility in water or dust). In contrast, phytoremediation is the process in which plants are used to extract/clean up contaminants within the soil.

Although the Surface Mining Control and Reclamation Act of 1977 allows for the use of introduced/ exotic species in reclamation efforts, the importance of restoring permanent native vegetation communities is widely recognized and accepted. Reasons for this often are that native species have a long history of genetic sorting and natural selection within a local environment. These adaptations often allow native species to survive, grow, and reproduce to a greater extent than introduced species in these areas harsh environments under many environmental extremes. In addition, the restoration of native plant communities often times have positive impacts upon recolonization and/or utilization by faunal populations.

Natural revegetation by native species has been demonstrated at various locations near Hurley. Additionally, large scale seeding efforts prior to determining the success of liming applications has significant cost implications. Therefore, disturbed areas will be stabilized with erosion fabric following amendment and will be allowed to naturally revegetate over the 2006 rainy season. This timing will allow suitable time for development of favorable soil conditions and increase survival of planted species. Areas that do not achieve substantial natural revegetation by May 2007 will be seeded prior to the rainy season. Substantial revegetation is measured by percent plant cover, which will achieve erosion and sediment control within the amendment study plots.

4.5.1 Seed Selection

There are generally two approaches to consider in the phytostabilization of areas addressed under this Work Plan. The first is an agricultural approach, where impacted areas are planted using introduced or cultivated species that have previously shown to be highly productive in similar environments and soil conditions. The second approach is an ameliorative/adaptive approach which involves amending soils in-situ, and identifying, specifying, and establishing plants that are ecotypically differentiated, or adapted to site conditions. This second approach is the preferred alternative in that it addresses biodiversity, self-sustaining plant communities, and thus wildlife habitat. A seed mixture was previously presented in the CCP that should allow for sustainable biodiversity.

Pilot Study Implementation

The Amendment Study will be performed on the four ¼ acre plots as shown on Figure 1. West of Hurley the vegetation/ rangeland condition is good and the pH of the soil is approximately 4.5 to 5. Therefore, spray application of the amendment will be performed in this area without tilling. A modified water truck will be utilized for the spray application. Application will be via automatic broadcast and manual spraying in rough terrain.

North of Hurley the vegetation/ rangeland is poor and the soil pH is 4.5 to 5. This area will require limited clearing and grubbing followed by spray application of lime and roto-tilling the soil. Clearing and grubbing will include removal of mesquite and boulders and large rocks from the amendment area to facilitate tilling.

The East A area vegetation/ rangeland condition is poor and the pH is approximately 2 to 2.5. Clearing and grubbing will be required to facilitate the application of the lime slurry and additional applications will likely be necessary to achieve acceptable pH soil conditions for revegetation.

East B area will be challenging due to the slope of the area (1.5:1 or greater) and a pH ranging from 2 to 2.5. The lime application will be sprayed without tilling to minimize erosion.

Clearing and grubbing of the areas, as described above, will be performed using a bulldozer and/or an excavator. The soils will not be significantly moved or excavated during this process. The metal teeth on the equipment will be used only to remove the vegetation.

The following table lists the specifications for each ¼-acre amendment plot.

Area	**Amendment**	**Application Rate** (Tons/acre as $CaCO^3$)	**Application Method**	**OM Addition/Rate** (Tons/acre)
West	Lime slurry	2.0 T/acre	Spray only	NA
North	Lime slurry	2.5 T/acre	Spray and Till	10T/acre
East A	Lime slurry	6.6 T/acre	Spray and Till	20T/acre
East B	Lime slurry	6.6 T/acre	Spray only	NA

The MSDS for the lime to be utilized during this work is included as an attachment to this work plan.

5.1 Control

One control area will be utilized to assist in tracking overall success of the amendment study. The control will be located near East A. The control plot will be tilled, but will not receive amendments. Analytical sampling will also be conducted within the control, however, only 2 sample locations will be identified within the control for soil collection and subsequent laboratory analyses.

5.2 Erosion Control and Best Management Practices

During the Amendment Study, erosion cloth will be applied upon completion of lime application to minimize erosion due to wind and rain. The fabric will be anchored using wooden or metal stakes. On steeper slopes, such as the North area and East A, fiber rolls will be installed along the slopes at approximately 30-foot spacing along the slope. The fiber rolls will act to reduce the velocity of sheet flow down the slope and will also act to hold some moisture on the slope.

Following application of lime and OM, as necessary, tilled areas will be left with furrowed ridges to aid in moisture retention and sedimentation control. These small ridges and valleys will serve to slow sheet flow and maximize infiltration of rainwater during vegetation reestablishment.

Sampling Plan

Soil characteristics are expected to be fairly homogeneous prior to amendment. Therefore, pre-amendment sampling will consist of 2 locations per ¼ acre plot. Each location will be sampled from 0 to 6" below ground surface (bgs) – within the target mixing zone – and from 1.5 to 2 feet bgs – below the target mixing zone. The deeper samples are intended to monitor the downward migration of amendments through the soil column. Leaching is not a concern as a caliche layer underlies the soil, however, NMED has expressed concern of the longevity of lime addition with respect to pH adjustment and solubility of copper. Therefore, the deeper samples will serve as baseline conditions prior to amendment and the initial rainy season.

Each pre-amendment sample will be laboratory-analyzed for:

- pH,
- calcium,
- nitrogen, potassium,
- total organic carbon (TOC)
- total copper, and
- copper solubility via synthetic precipitation leaching procedure (SPLP).

The target amendment zone is as deep as 8-inches bgs.

Three rounds of post-amendment sampling will be conducted at 2-weeks, 6-weeks, and 6 months following amendment. Eight locations will be selected and sampled per ¼ acre plot. Soil will be collected from each location at depths of 0-6 inches bgs and 1.5-2 feet bgs. Samples will be analyzed for:

- pH,
- calcium,
- nitrogen,
- TOC
- total copper,
- and copper solubility via SPLP.

BBL will perform a limited field plant survey in the areas proposed for tilling approximately 6 week and 6 months following amendment to assess natural revegetation within the disturbed areas. Prior to conducting monitoring of pilot study areas, BBL will survey comparable reference sites to determine species composition and total percent cover of native taxa. Standard vegetation sampling protocols will be followed to identify species composition and percent cover throughout the proposed impacted areas. Percent cover of native species between 70 to 100% of the average percent cover observed at reference sites will be considered a successful re-growth during the first 6-months following amendment.

The monitoring field efforts are also intended to identify additional native species that are able to succeed under the 'new' soil conditions (i.e., normalized pH, lower metal concentrations). disturbed areas that do not attain substantial plant regrowth (defined as 70-100% of the average percent cover of surrounding areas) will be revegetated prior to the 2007 rainy season according to the seed mix specified in the CCP.

Analytical Methods

The following table provides analytical methods to be used during the pilot study pre-amendment sampling and subsequent monitoring.

Parameter	Analytical Method	Glass Jars	Preservative
pH	9045C	8 oz	N/A
Calcium	6010B		N/A
Nitrogen	350.1, 353.2, 351.4		N/A
Potassium	6010B		N/A
Total Organic Matter	Handbook 60		N/A
Copper Solubility (total copper and SPLP)	1312 extraction, 3010A digestion, 6010B analysis		N/A

N/A = not applicable for this method

Data Quality, Management, and Interpretation

Data will be managed in accordance with Standard Operating Procedures (SOPs) which were developed as part of the RI Quality Assurance Plan (QAP) (Chino, 1997a).

Analytical methods listed in Section 7.0, above, will provide data of sufficient quality to asses the efficacy of this Amendment Study. Data are to be used to assess appropriateness of this technology for full-scale implementation; as such data quality objectives (DQOs) are limited to pilot-scale activities.

The DQOs conceptually include:

- Total copper reporting limits must be below target cleanup levels for copper;
- Data must be of sufficient quantity to assess coverage and uniformity of amendment within each test plot; and
- Data must be of sufficient reporting limits and validated quality to assess the longevity of the amendment – and copper solubility – within the target mixing zone of 8-inches bgs.

Data interpretation will be performed as part of reduction or pre-amendment sampling as well as the three subsequent monitoring sampling events. Interpretation will be performed in support of decision criteria for full-scale implementation of this technology. Decision criteria (described in Section 3.0) include:

- Reduced solubility of copper within the top 6-inches of soil as compared to pre-amendment baseline conditions. The target percent solubility reduction will be determined after pre-amendment soil samples are analyzed and interpreted. For the purpose of this Amendment Study, the percent reduction is a quantitative measurement with target to be set as part of this Study;
- Sustained pH levels within the target range of 5.5 to 6.5 during the 6-month monitoring period;
- Increased plant cover percentage as compared to existing vegetation and the control plot. Target for this Amendment Study is 70-100% plant cover as compared to the average percent plant cover within surrounding areas (considered baseline). Composition or speciation will not be used as a metric as several years may be necessary to develop plant diversity during natural revegetation; and
- Improved soil chemistry (e.g., C/N ration and concentration of nutrients) is sustained over 6-month monitoring period. C/N ratio stability over 6-months will provide a measurement of longevity of the OM addition within the target mixing zone of 8-inches bgs. Improved chemistry is assumed to have been achieved if the C/N ratio after amendment is higher than pre-amendment ratios. Sustainability of the increased C/N ratio is the true metric for performance and permanence.

Based on an analysis of the decision criteria, a decision will be made as to whether to proceed with full scale implementation. If Chino determines that it is practical to proceed, then a formal interim action work plan will be submitted to NMED. The interim action work plan will include details with respect to long-term monitoring which is an important aspect of understanding the long-term sustainability of the amendments which this pilot study will not address. The pilot study will provide enough information to make a decision on whether to proceed but will not address long-term sustainability because only monitoring over a number of years will provide assurance that the amendments are successfully working.

Applicable or Relevant and Appropriate Requirements

Applicable or Relevant and Appropriate Requirements (ARARs) are defined in CERCLA as:

- Any standard, requirement, criterion, or limitation under any Federal environmental law, such as the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Marine Protection, Research, and Sanctuaries Act (MPRSA), and the Resource Conservation and Recovery Act (RCRA)
- Any promulgated standard, requirement, criterion, or limitation under a State environmental or facility-siting law, including those contained in EPA-approved programs, that has been identified by the State to EPA in a timely manner. (EPA, 1992).

ARARs are typically not developed for treatability studies. ARARS for full-scale implementation will be developed and explained within the Amendment IAWP, to be developed after completion of this Amendment Study.

Health and Safety

The "Investigation Area Health and Safety Plan" (HASP) was developed for Chino in January 1997 to address and mitigate potential worker exposure during site activities. Levels of personnel protective equipment and monitoring during activities will be determined based on the 1997 HASP and hazards associated with each work task. The site-specific BBLES Health and Safety Plan, dated January 2006, will also be utilized for activity-specific information and monitoring requirements.

All parties involved in the STSIU pilot study will complete activities in accordance with the 1997 HASP and the site-specific HASP.

The primary routes of exposure to site COCs are:

- Inhalation of particulate and dust generated during work activities; and
- Incidental ingestion of constituents from direct contact with soil and dust, and from air emissions.

Site-specific engineering controls and monitoring will be employed to reduce exposures and ensure the safety of workers. Air monitoring will be conducted for compliance with New Mexico Air Quality standards within the work area. Dust suppression will be achieved by applying water to the ground surface during dust generating activities. If applying water is not sufficient to reduce airborne particulate, work activities will be suspended until ambient conditions return.

The following table outlines air monitoring requirements in the site-specific HASP.

Parameter	Reading	Action
Airborne Particulates	0 to < 0.5 mg/m^3	Normal operations; continue hourly breathing zone monitoring
	$\geq 0.5\ mg/m^3$ to $1.5\ mg/m^3$	Initiate dust suppression measures and increase monitoring frequency to every 15 minutes; if suppression measures are insufficient to maintain particulates below $1.5\ mg/m^3$, stop work until dust levels can be maintained below $1.5\ mg/m^3$
	$> 1.5\ mg/m^3$	Stop work until dust levels can be maintained below $1.5\ mg/m^3$

Residuals Management

PPE, gloves, and other disposable equipment shall be placed in garbage bags and disposed of in a trash collection facility. Wash and rinse water and soil shall be disposed of on the ground surface at the sample location in accordance with the SOPs.

References

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LEGEND:

- TAILING PONDS
- CITY LIMITS
- DUE TO CLIFF-LIKE TOPOGRAPHY, INTERIM ACTION WILL BE LIMITED TO OPEN AREAS
- AOC BOUNDARY
- DRAINAGE
- AMENDMENT AREAS
- APPROXIMATE UPLAND AREA WITH SOIL COPPER > 5,000 MG/KG
- APPROXIMATE UPLAND AREA WITH SOIL COPPER < 5,000 MG/KG AND > 2,700 MG/KG
- SMELTER / TAILING OPERATIONAL AREA

0 1,000 2,000 Feet
GRAPHIC SCALE

8/15/06 BRI-85 TBR SYR-85 KEW PET-85 EGH
Cino Mines Company (63506.004)
Q:/PhelpsDodge/Chino/SmelterTailing/mxd/SiteOverview_Fig1.mxd

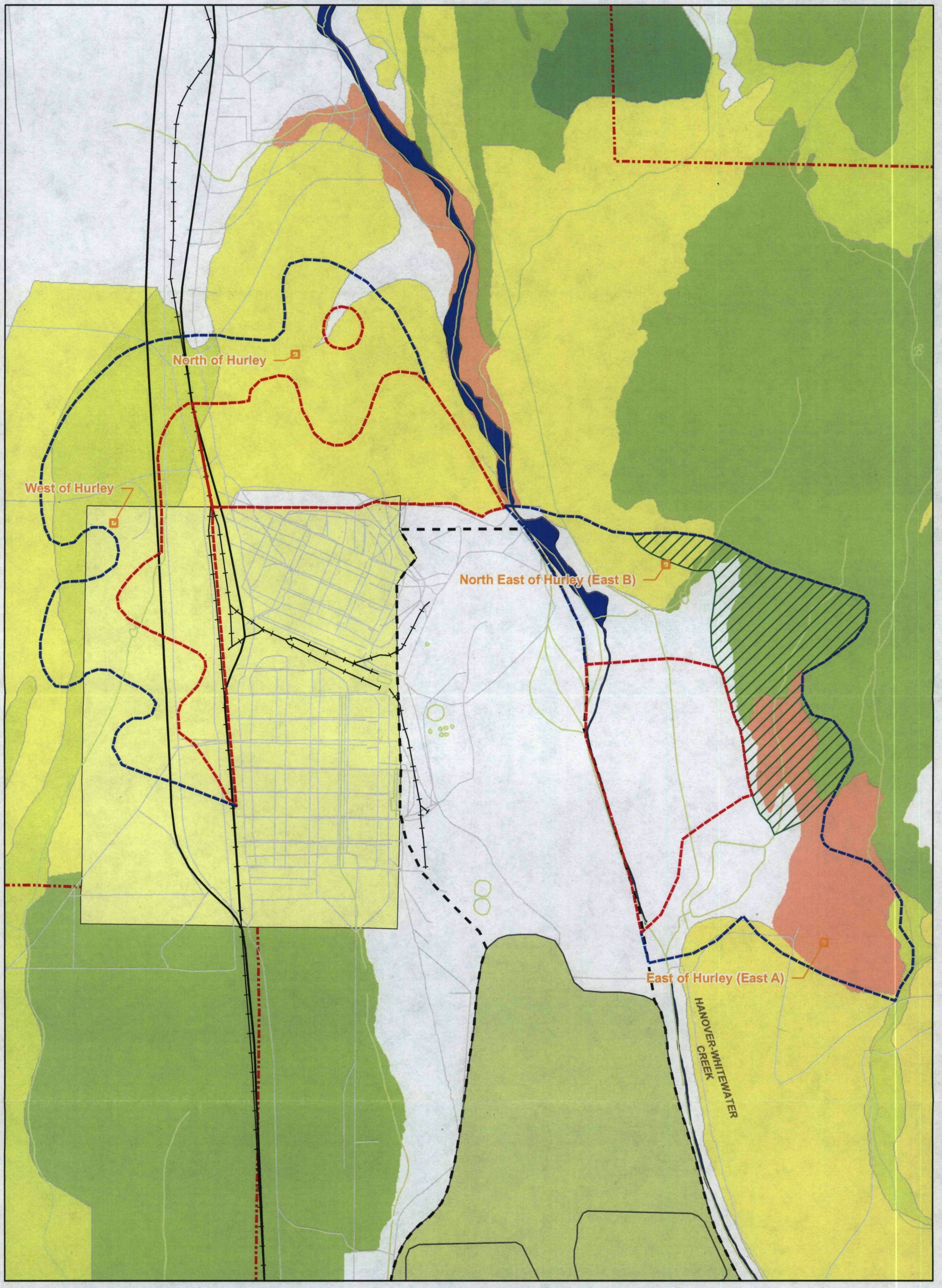
CHINO MINES COMPANY
HURLEY, NM

AMENDMENT STUDY WORK PLAN

SITE OVERVIEW

BBL an ARCADIS company

FIGURE
1



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- SMELTER / TAILING OPERATIONAL AREA

RANGELAND CONDITIONS

- EXCELLENT
- EXCELLENT - GOOD
- GOOD
- GOOD - FAIR
- FAIR
- FAIR- POOR
- POOR

0 1,000 2,000 Feet

GRAPHIC SCALE

CHINO MINES COMPANY
HURLEY, NM

AMENDMENT STUDY WORK PLAN

RANGELAND CONDITIONS

BBL an ARCADIS company

FIGURE 2

8/15/06 BRI-85 TBR SYR-85 KEW PET-85 EGH
Cino Mines Company (63506.004)
Q:/PhelpsDodge/Chino/SmelterTailing/mxd/RangeLand_Fig2.mxd